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With only California experience as a background, this paper does not adequately present conditions or development elsewhere; however, one must look beyond the boundaries of this state for historical data on cutback asphalts prior to 1929. It appears that the first use of cutback asphalts was made by Mr. Prevost Hubbard in the grounds of Cornell University in 1909. While there is no doubt that solvents were used with asphalts more than twenty years ago, nevertheless the amount consumed in the United States in 1919 was still quite small and used mainly for surface treatment, and in the preparation of cold patch mixtures.

Mr. A.H. Hinkle reports that a few barrels were tried out in Ohio in 1917. High prices, particularly of the gasoline solvent, hindered further work until 1922 or 1923, when further experiments were made in the state of Indiana under Mr. Hinkle's direction. Within a short time, shipments were being made in carload lots and used for surface treating traffic-bound roads.

The practice of blading or dragging stone chip surfaces was developed about the same time, and the so-called retread type of construction came into existence using a comparatively light grade of cutback which would permit the necessary preliminary blading and mixing in place.

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CUTBACK ASPHALTS

By
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II. CHANGES EFFECTED BY RAPID DEVELOPMENTS IN THE FIELD OF LOW COST CONSTRUCTION

Cutback asphalts were introduced in the West in 1929 with the construction of the Cooperative Experimental Section on U. S. Route 40 between Truckee and Reno. This experimental pavement was constructed under the joint supervision of the U. S. Bureau of Public Roads and the State of California.[1]

In 1930, a section on the shores of Clear Lake in Lake County, California, was constructed using a dense-graded aggregate road mixed with cutback approximating the present MC-3 grade.

The very successful results obtained led to a considerable increase in the use of cutbacks, particularly of the medium curing type. Roads constructed with this material were regarded with considerable favor, and were thought to represent a marked improvement over the first types built with slow-curing oil. The cutback roads seemed capable of withstanding more severe weather conditions, and there was a considerable tendency to prefer cutback asphalts to the SC types.

III. PROGRESS IN SIMPLIFICATION AND STANDARDIZATION OF GRADES

In view of the fact that all of the states were carrying on development work in bituminous road construction more or less simultaneously, there arose a considerable disparity in ideas as to the exact grades of oil or asphalt required. This independent development naturally resulted in different specifications for every state or county organization, with the result that at one time the producers in California were furnishing asphaltic materials under nearly 300 separate specifications.

This very troublesome, expensive, and altogether absurd situation obviously required some simplifications, and as a result of the joint efforts of the Asphalt Institute, the Bureau of Public Roads, and the various states, between the years 1930 and 1934 a simplified system was established which is being essentially followed today. The present classification of materials under slow curing, medium curing, and rapid curing type is too well known to require repetition here.

Further attention is now being directed to the rather unsystematic consistency ranges which were more or less arbitrarily selected for the various grades. There have been recent proposals submitted for the readjustment of the group, in order that each particular numerical designation will cover the same viscosity range at the same normal temperature of 140°F. If this further step can be made, it will be of marked advantage to the men who actually use and apply the asphaltic materials.

The first oil work on State Highways in California in 1924 was of the surface treatment type, with subsequent development of armor coats and retreads. At that time, frequent use was made of asphalt ranging from 150 to 200 penetration, also commonly known as 95+ road oil. Experience indicated that this grade was often too heavy for use on construction through the Redwood regions along the north coast, and it was found that a lighter grade designated as 90-95 oil was generally more satisfactory. With the advent of cutbacks, experiments were soon made with MC cutbacks using this 90-95 road oil as a base.

Results appeared to be no less satisfactory than with heavier grade asphalt, and as time went on, the road oil cutbacks proved to be more workable for road mix construction and were definitely superior for stockpiled storage of premix. As a result, when the simplified schedule was adopted in our 1935 Standard Specifications, an additional series of cutback materials was included following the standard designations, but classed as road oil medium curing products, with grades ranging from ROMC-1 to ROMC-5. This particular series of cutback asphalts has continued to be very satisfactory, and their use has increased steadily, first for road mix constuction, and finally for plant mix work. The ROMC cutback is in no respect inferior to the standard MC grade, and has the distinct advantage of having less tendency to become brittle, and is workable under a wider range of conditions.

At the present time, if further simplification is desired, consideration might be given to the elimination of the present MC grade and the substitution of the ROMC therefor. In other words, medium curing cutback might be based on a 90-95 heavy road oil rather than 110 penetration asphalt.

IV. DEVELOPMENTS IN THE TESTING OF CUTBACK ASPHALTS AND PAVING MIXTURES IN WHICH THEY ARE USED.

The first cutbacks were specified in terms of the amount and character of the solvent and the amount and grade of the asphaltic material before blending. With the standardized practice, we abandoned any attempt to control the original ingredients, and specified tests on the finished product by means of distillation to determine the percentage of solvent, and penetration or float tests on the residue to establish the consistency of the asphaltic material. It is probable that the tests prescribed for cutback asphalts are neither better nor worse than those in use for other asphaltic materials. They are almost entirely identification tests, and a considerable variety of asphaltic materials will get by the specifications. These test procedures represent an attempt to cover the outstanding characteristics of those products which were previously giving satisfactory performance.

Producers naturally try to adjust their operations so that their product will meet any new specification. This is a more or less logical and inevitable development. Nevertheless, we are sometimes confronted with the disturbing fact that materials can be manufactured which will meet all the specification requirements and still prove to be relatively unsatisfactory in service. Probably most highway engineers have encountered some such experience.

It would be quite appropriate at this point to suggest test procedures which would always insure satisfactory grades of asphalt. However, the best that can be offered is to suggest those qualities of asphalt which need to be measured in advance. First is consistency, which is taken care of with reasonable satisfaction by penetration, float, and viscosity measurements. Second is ability of the asphalt to adhere to the mineral aggregate in the presence of water, and while tests to measure adhesion are now in use, they are usually used to classify the aggregate rather than the asphaltic material. Third, and most important, is the durability, or tendency of the asphaltic binder to become brittle with age. But at present no satisfactory means are in general use to determine service life.

A further requirement for the various liquid asphalts, particularly cutbacks, would be some measure of the rate of curing or setting up in service. While the distillation test is presumed to indicate the rate of curing, experience with actual construction has shown that behavior on the road is considerably affected by the porosity and moisture content of the aggregate. It seems quite evident that any test for curing must take into consideration the particular mineral aggregate and the local weather conditions.

Experience of various kinds is slowly accumulating which indicates that some attention must be given to the suitability of both solvent and asphalt used in the manufacture of cutbacks. In other words, it appears to be a question of compatability, and while it is difficult to cite any positive evidence in either direction, it can be stated that material differences have been observed which seem to depend upon the type of solvent added to a given asphalt base.

For example, it is well known that certain low boiling point solvents representing a narrow fraction have the capacity to flocculate either heavy molecules or colloidal hydrocarbons, and under suitable conditions cause these heavier fractions to precipitate out as asphaltenes. The Oliensis spot test, or the solubility test in petroleum ether, are examples.

However, a few solubitity tests made on California asphalts with commercial cutter stocks of the MC type brought no evidence to justify this suspicion. Nevertheless, certain cutback asphalts have been observed which show marked changes in viscosity within a few days after manufacture. The float viscosity may increase as much as 30% within two or three days, and the materials give considerable difficulty during construction. The exact mechanism of this false viscosity phenomenon is not well understood, but it is apparently associated with the blending of gas oil types of solvent with a heavy asphalt which probably has low tolerance for further dilution by the solvents.

Mr. Norman McLeod reports that tank cars of cutback have been received in Canada in which a precipitation of asphaltenes had occurred. This effect was confined to the MC-1 grade, however.

In an attempt to ascertain whether or not any changes might occur in an asphalt binder due to the presence of a cutter solvent, tests were made in the California Laboratory to compare the effect of weathering influences on an E grade asphalt and on the same material after mixing with solvent to form a cutback. Results are shown below:

Two grades of asphalt were selected, one of 50-60 penetration, and one of 120 to 150 range. Four samples were used representing the product of two separate refineries. Base A and B came from one refinery and C and D from another source. Cutback asphalts were prepared in the Laboratory using cutter stocks of both RC and MC types, and for further comparison, one set of cutbacks were prepared using kerosene extract.

The base asphalt and prepared cutbacks were spread in thin films on metal slides and placed in a constant temperature oven maintained at 300°F. The slides were removed from the oven at intervals and tested for brittleness by bending over a 3/4" cylindrical mandrel, and the elapsed time in the oven recorded.

Table I shows the length of time required to produce a brittle film for each of the several samples of base stock and cutback mixtures tested. Test results show clearly that in all cases samples became brittle and cracked sooner after being blended with cutting stock than was the case with the original asphalt. It should be noted that in order of quality the original asphalt gave the best results, kerosene extract next, MC stock third, and the RC solvent fourth place. While far from conclusive, it is believed that the results shown herewith indicate the need of further investigation into the effects of adding solvents to asphaltic materials.

TABLE I

ASPHALT			CUTTING STOCK USED			
	Penetration Range 50-60	120-150	NONE	Kero. Ext.	MC	RC
Refinery 1	A		7½			5½
		B	8½	7	6½	
Refinery 2	C		8½			4½
		D	11½	9½	8½	

Little work has been done in studying the adhesiveness of cutback asphalts with various types of hydrophilic aggregate, although it has long been suspected that the type of cutter stock used, as well as the type of asphalt, might have some bearing on this property. Quoting briefly from a report by Geissler and Kleinert:[2]

> While most commercial cutbacks adhered well to hydrophobic and poorly to hydrophilic aggregate nevertheless important changes in adhesive qualities could be produced by special selection of the cutting stock.

In order to discuss tests of paving mixtures in which cutback asphalts are used, it is necessary to outline briefly some of the essential qualities of satisfactory paving mixtures. While many cutback mixtures have been plant mixed with a carefully controlled grading of aggregate, nevertheless the material has been used in the West largely as a substitute for slow curing oils, and the principles of mixture design for cutback asphalts are little, if any, different from those applying to any oil mix.

Experience throughout the Western states has demonstrated that very satisfactory results have been obtained with aggregates representing a wide range of gradation, density, and particle hardness; and studies over a wide range of work indicate that stability, in particular, is dependent upon none of these properties. The first few years of oil mix construction demonstrated that roads using a very light road oil as a binder were in a great many cases showing absolutely no sign of distortion or failure under heavy traffic. On a warm day these roads can, for the most part, be readily scarred or dug up with a pointed stick; therefore, the stability of bituminous pavements does not depend entirely on the hardness of the asphalt binder.

Without giving in detail the various experiments which were made to determine the fact, it may be stated that the stability of bituminous mixtures depends largely on the frictional resistance between the particles of mineral aggregate. This sliding resistance is highest when the rock particles have a rough, sandpaper-like texture, and when there is no excess of oil or water present. It is at a minimum with smooth, polished stone particles and with an excess of oil or water or both.

In other words, the well known factors which influence friction and lubrication seem to apply directly to the problem of stability of bituminous mixtures. It has been noted, however, that unstable plastic mixtures will require a longer time to develop appreciable distortion with a hard asphalt than with a road oil. Therefore, cohesion or tensile strength does have an influence, and stability of the pavement is due to the presence of two properties, which may be roughly described as friction and cohesion.

The Stabilometer was developed to measure the relative stability of oil mix pavements, and the test values represent particle friction almost entirely. The same equipment and procedures have been applied to cutback asphalt mixtures as a logical development. Cutback asphalt, however, supplies greater cohesion or tensile strength to a pavement mixture, and this fact can be utilized in the treatment of smooth, rounded gravel, which often does not give stable surfaces.

with slow curing oils. The testing of cutback paving mixtures is only one item in the field of testing all types of bituminous mixtures, and inasmuch as stability is due to two properties, namely, friction and cohesion, it is possible to compensate for lack of friction by using a heavier asphalt binder, which increases stability by increasing the cohesion or tensile strength. A full discussion of the use of Stabilometer data has been presented elsewhere.[3]

In the early days, the use of cutback asphalts brought out the fact that there is considerable variation in the rate of setting, or curing on the road. Reports based on Eastern experience have indicated that cutback asphalt should only be used with open-graded types of construction to permit aeration, and allow the solvent to escape by evaporation. There has also been considerable discussion and difference of opinion among western engineers as to the need for a curing period before consolidation. Experience in California has not indicated that a preliminary curing period is often necessary, even with dense-graded mixtures, undoubtedly due to the fact that in this state we make a consistent effort to use a cutback with the least amount of solvent possible. For this reason, an extra-heavy grade of MC cutback is included in our specifications. This grade uses approximately 11% of kerosene solvent, and is intended for plant-mix construction. It requires no aeration period prior to consolidation.

Several years ago, an attempt was made in California to predict the setting period for cutbacks using 15% or more of solvent by means of a distillation operation carried out on a sample of the freshly mixed material taken from the road. It was found that those mixtures which would set up properly usually gave off less solvent in the test than did the samples which seemed to require aeration. As stated above, however, the importance of this determination seemed to diminish, and the method was not pursued further.

The procedure was taken up by the Arkansas Highway Department, and in a letter dated January, 1937, Mr. Fred G. Allison states that some investigations were made and they found a considerable variation in the volatility of cutbacks even with materials of the same grade.

A more complete report on methods of recovering solvents from cutback mixtures is contained in a paper by Mr. R. E. Bollen[4] of the Nebraska Highway Department. This procedure involves a reflux condenser using a soda ash solution and appears to be highly satisfactory for the purpose. It is our intention to adopt this method whenever such determinations are necessary.

V. BEGINNING OF THE ERA OF SUBGRADE STABILIZATION

Probably the most widely used and misused term in highway work today is "soil stabilization." This term seems to need some clarification. The student of semantics would say that we need to agree upon proper referents for the word "stabilization".

In a recent paper Roediger and Klinger[5] have proposed an additional classification, as follows: (1) Compaction Stabilization, (2) Water Proofing Stabilization, (3) Dilution

Stabilization, (4) Cementitious Stabilization, (5) Chemical Stabilization.

If engineers are to avail themselves of a wide range of experience, it is necessary that the matter of nomenclature be given serious consideration. For example, Westerners are under the general impression that they were building rather efficient low cost pavements by the use of liquid asphalts combined with the local sandy or gravelly soil. It now appears that this class of work comes under the heading of stabilization, and if this is true, there would seem to be no logical reason why any type of construction which involves mixing mineral aggregate with an artificial binder should not also be included. Thus all the pavement types except brick or wood block would be covered, and the term stabilization would include practically everything.

It seems that the term "stabilization" might well be confined to treatments of soils for foundation purposes, and might be further restricted to soils which are originally unsatisfactory.

So far as soil stabilization with cutback asphalt is concerned, little work of this sort has been done in California, and no first hand experience can be cited.

The Asphalt Institute publications, particularly the booklet, Construction Series No. 40, describe considerable experience in Florida, the Carolinas, and Nebraska. The paper by Mr. Roediger and Mr. Klinger referred to above contains considerable data on laboratory tests as well as construction methods.

will require continued investigation, at the present time there is a very pressing one which applies to all asphaltic materials used in highway construction, and that is the need to determine durability, or the capacity of an asphalt to retain its initial characteristics. As lack of durability virtually means undue tendency to become hard and brittle, it can be stated that we need accelerated tests to determine the tendency of an asphalt to become hard and brittle and lose the plastic properties which are so essential to good performance.

As stated previously, there is considerable reason to believe that cutback asphalts often have a greater tendency to become hard and brittle than would the original asphalt without the addition of solvent. The following is a quotation from a report by Lewis and Hillman:[7]

> All the cutbacks, while losing but little weight after two days' exposure, were much harder and had much less ductility at the end of five weeks' exposure than the original asphalt used as base material.

This problem is being attached from a number of different angles, and probably several feasible solutions will be forthcoming. However, it seems most probable that any test which will square up with service performance must closely simulate the condition of actual service, namely, the exposure of the asphalt in thin films to light and heat of proper intensity.

Mr. A. R. Ebberts states that the changes which occur in asphalts are apparently due to a photo-catalytic oxidation reaction.

Another problem requiring investigation concerns the ability of asphalts to adhere to mineral aggregates and resist stripping due to water. This investigation will naturally include variations which are known to exist in the asphalt products already available, and also means to improve wetting characteristics by special treatment. The work of Dr. Hans Winterkorn using Furfural, and procedures outlined by Mr. Norman McLeod[8] are examples of the possibilities along this line.

At the present time, it would seem that if the two problems of durability and adhesion can be properly answered, we should have little else to worry about. While better measures of consistency are required, it is probable that satisfactory viscosimeters are already in existence which would enable us to report all asphaltic materials in the same scale of fundamental units.

VII. PROBABLE FUTURE TREND

While cutback asphalts are usually considered as materials of the MC and RC groups, and the SC products regarded as residual oils, nevertheless, many slow curing products, even asphaltic cements, are manufactured by blending or fluxing. Therefore, it is not inconsistent to regard virtually all of the road building asphalts as actual or possible cut-backs. With this thought in mind, it can be stated with considerable confidence that there will be no falling off in the use of cutback asphalts, although there may be a change in the type and amount of solvent or fluxing oil which is used.

It is not unlikely that future specifications will require that all bituminous materials have certain essential oily or resinous fractions.

Tests to determine durability may be made by means of either accelerated weathering, or through Laboratory oxidation tests.

So far as grades are concerned, the present trend would seem to focus on the increased use of SC-4, SC-5, and SC-6 grades, with or without the addition of lighter solvents to promote workability.

However, changes in petroleum refining practice due to new discoveries and methods of producing gasoline and lubricating oils may have a marked effect on the type of residuum available for highway use. Recent announcement of catalytic cracking process on a commercial scale leads one to wonder whether or not the residue will prove to be that dream of the bituminous paving technologist - a bitumen with the adhesive qualities of tar, the workability of cutbacks, and the durability of the best asphalts.

BIBLIOGRAPHY

1. T. E. Stanton and J. T. Pauls
   "Experience with Road Mixes and Surface Treatments in California" Public Roads, January, 1935

2. Geissler and Kleinert
   "Adhesiveness of Cutbacks on Mineral Aggregate" Asphalt und Teer, No. 25, 26, 28, 1936

3. T. E. Stanton and F. N. Hveem
   "Role of the Laboratory in the Preliminary Investigation and Control of Materials for Low Cost Bituminous Pavements" Proceedings of the Fourteenth Annual Meeting of the Highway Research Board, December, 1934, Part II.

4. R. E. Bollen
   "Bituminous Research in Nebraska" Proceedings of the Montana Bituminous Conference, 1937, Page 104 - 105

5. J. C. Roediger and E. W. Klinger
   "Soil Stabilization Using Asphalt Cutbacks As Binders" presented at the meeting of the Association of Asphalt Paving Technologists in Chicago, 1939.

6. Paul F. Critz and H. L. Sligh
   "Experimental Bituminous Treatment of Sandy Soil Roads" Public Roads, January, 1937

7. R. H. Lewis and W. Hillman
   "Further Studies of Liquid Asphaltic Road Materials" Public Roads, August, 1935

8. Norman W. McLeod
   "Applications of surface Chemistry and Physics to Bituminous Mixtures" Proceedings of the Association of Asphalt Paving Technologists, 1937.